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# LETTUCE GROWING

## IN GREENHOUSES



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U. S. DEPARTMENT OF AGRICULTURE

**H**IGH-QUALITY lettuce can be grown in greenhouses during the winter months, when it is not possible to grow lettuce outside in most parts of the country. Most of the lettuce grown in greenhouses is of the nonheading type, which has a high vitamin content and is superior in this respect to head lettuce.

Lettuce can be grown in almost any type of greenhouse that will provide the proper light and temperature; however, large houses of modern construction, provided with a modern heating plant, give best results.

Usually other forcing crops, tomatoes and cucumbers, are grown in rotation with lettuce, but some large establishments are devoted exclusively to lettuce. Lettuce works well in rotation with tomatoes and cucumbers; in this way the greenhouse space can be used during the winter when growing conditions are not favorable for either cucumbers or tomatoes.

The grower of greenhouse lettuce has many of the problems of the grower of field lettuce. Successful production of lettuce in greenhouses requires that the soil be maintained at a high level of fertility, that diseases, insects, and other pests be controlled, and that only the best adapted strains be grown.

With intense competition of field-grown head lettuce, satisfactory financial returns from greenhouse lettuce can be expected only when a high-grade product is marketed in an attractive package and delivered to the consumer in a fresh condition.

# LETTUCE GROWING IN GREENHOUSES

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**T**HE GROWING of lettuce under glass is one of the oldest vegetable-forcing industries. Lettuce is well adapted for forcing during the colder months of the year, when light and temperature are less favorable for other vegetable forcing crops. Much lettuce was grown in hotbeds and coldframes before greenhouses came into general use for the growing of vegetables. Some lettuce is still grown in frames in early spring and late fall, when only limited protection from cold is required. However, most of the forced crop is now grown in greenhouses especially designed for growing vegetables. The use of greenhouses has made it possible to supply the market with fresh lettuce throughout the winter, when the weather is too cold for the growing of crops in frames.

With the expansion of the field-grown lettuce industry into regions with mild winters, there was a gradual decline in the demand for greenhouse-grown lettuce. Although field-grown head lettuce can now be obtained in most markets the year round, there is still a demand for high-quality, greenhouse-grown lettuce during the winter. The growing of lettuce under glass still constitutes a sizable industry in certain districts where its production has become highly specialized and the winter market has been well organized and maintained. The industry has now become fairly well stabilized. There is reason, however, to expect further reduction in the production of greenhouse-grown let-

<sup>1</sup>The original version of this bulletin was prepared by James H. Beattie, senior horticulturist, Division of Fruit and Vegetable Crops and Diseases.

tuce because of competition from field-grown head lettuce, and expansion of the industry is not likely.

The greenhouse-lettuce industry had its beginning about 1885 in the vegetable-growing district around Boston, Mass. The success of the Boston growers led to the development of lettuce forcing in other Northern States. An important greenhouse forcing industry soon grew up around Grand Rapids, Mich., and this was followed a little later by a large forcing industry in northern Ohio around Ashtabula, Cleveland, and Toledo and around Rochester, N. Y., Philadelphia, Pa., and other large centers of population.

In spite of the competition from field-grown lettuce, the forcing of lettuce, chiefly leaf lettuce, remains an important industry in some of the districts where it first developed. At present the industry centers around Boston, Mass., Grand Rapids, Mich., Rochester, N. Y., and Ashtabula, Cleveland, and Toledo, Ohio.

The growing of lettuce in greenhouses is an expensive and highly specialized business, and it should not be undertaken without practical knowledge in the growing and marketing of the crop.

### LOCATION AND CONSTRUCTION OF GREENHOUSES

Since many growers of greenhouse lettuce grow other crops also, they should consider the requirements of these crops in any plans for the construction of new houses. Lettuce, tomatoes, and cucumbers are the important vegetable forcing crops, and many growers grow all three of them at different seasons. Good light is essential for the growing of lettuce under glass. Since lettuce is grown chiefly during the winter, when the days are short and there are many hours of dull, cloudy weather, it is important that greenhouses be constructed so as to afford the maximum of light. It is important that temperature be properly controlled and that drafts be reduced to the minimum consistent with good ventilation. Efficient heating equipment is essential.

#### LOCATION

Some important points to be considered in locating a greenhouse for vegetable forcing include the following: (1) Nearness to market, (2) availability and cost of labor, (3) supply and cost of fuel, (4) soil suitable for the crops to be grown, (5) water supply, and (6) freedom from smoke and fumes from railroads and industrial plants.

The type of lettuce grown in greenhouses is not so well adapted for long-distance shipment as the hard-headed type grown in the field. It tends to wilt quickly unless it is kept moist and cool; therefore it is more difficult to deliver on the market in a fresh, firm condition. The delicacy of the product and the cost of transportation make it imperative that the crops be grown relatively near the consuming market.

Labor today is a major item in the cost of almost all commodities, agricultural as well as industrial. Capable, well-trained help is often difficult to obtain. The available labor supply should be kept in mind in locating new greenhouses for vegetable production.

The cost of fuel has always been a large item of expense in greenhouse maintenance. Fuel cost has advanced sharply in recent years. Soft coal has always been the chief source of fuel for greenhouse heating, but oil has replaced coal to some extent.

Although the soil used in greenhouses can be made to suit the crop to be grown by the addition of fertilizer, organic matter, lime, and other soil amendments, it is highly desirable that the range be located where the soil is naturally suitable for the crops to be grown. The lighter types of soil are preferred for greenhouse vegetable production.

The importance of water in vegetable growing is too obvious to require much discussion. There should be an adequate and constant supply of water free of materials that may be toxic to plants or that may corrode the heating system. Water highly chlorinated in filtration plants is not desirable. A high concentration of alkaline salts should be avoided.

Smoke from railroad yards and industrial plants reduces light intensity through its presence in the air, and soot from such sources forms a film on the surface of the glass, which greatly reduces the intensity of the light that reaches the plants. Any reduction in the already low light of dull winter days by smoke, soot, or residue from fumes should be avoided. The fumes from some industrial plants may be toxic to certain plants. Greenhouses should not be located close to plants emitting such fumes.

#### CONSTRUCTION

Most of the newer greenhouses built for the growing of lettuce are even-span houses of steel or semisteel construction. The lean-to type of greenhouse is not suitable for commercial lettuce growing. The three-quarter- or uneven-span house (fig. 1), which has been used



Figure 1.—End view of two three-quarter- or uneven-span greenhouses, a type of house formerly used extensively in the Boston district.

extensively in the Boston district, is used much less than formerly.

Since other crops are usually grown in rotation with lettuce, the requirements of all the crops to be grown should be considered in planning the greenhouse construction and the arrangement of beds and benches. Lettuce can be grown in almost any type of greenhouse in which the lighting is good.

The ridge-and-furrow type of construction (fig. 2) is widely used to enclose a large area under one roof. This type of structure permits an almost unlimited area to be enclosed with a minimum of obstructions to interfere with cultural operations and the entrance of light.

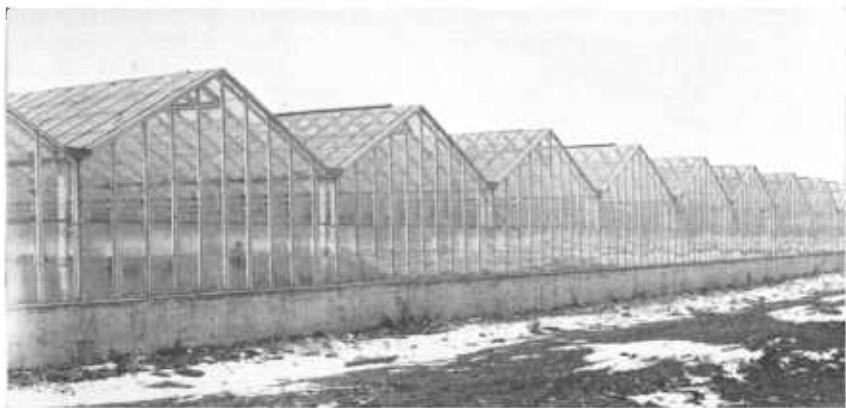


Figure 2.—Ridge-and-furrow type of greenhouse, which permits enclosure of very large areas under one roof.

Large even-span steel-frame houses (fig. 3) have come into wide use for vegetable forcing. The use of steel in the framework adds greatly to the strength, rigidity, and life of the house. This type of construction affords better lighting than the old-style wood-frame houses since many of the interior supporting posts have been eliminated.

Most greenhouse lettuce is grown on ground beds. In large ranges the entire floor of the house is fertilized, plowed, and tilled in much the same manner as a field.

### LETTUCE VARIETIES FOR FORCING

Of the many lettuce varieties, only a few are suitable for forcing. In the past, numerous varieties of heading, cos, and leaf lettuce were used for growing under glass, but now two or three constitute almost the entire commercial crop. The two most important greenhouse forcing varieties are Grand Rapids and Bel-May (fig. 4).

Growers in the Boston district have always grown head lettuce, and now this district is the only important greenhouse forcing center where head lettuce is grown in quantity. In the past, Belmont, May King, Big Boston, and Salamander were grown under glass with varying success.

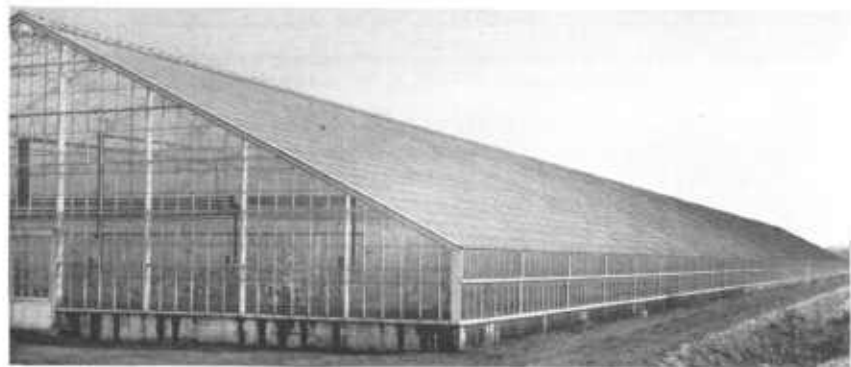


Figure 3.—Steel-frame house, ideal for vegetable forcing.

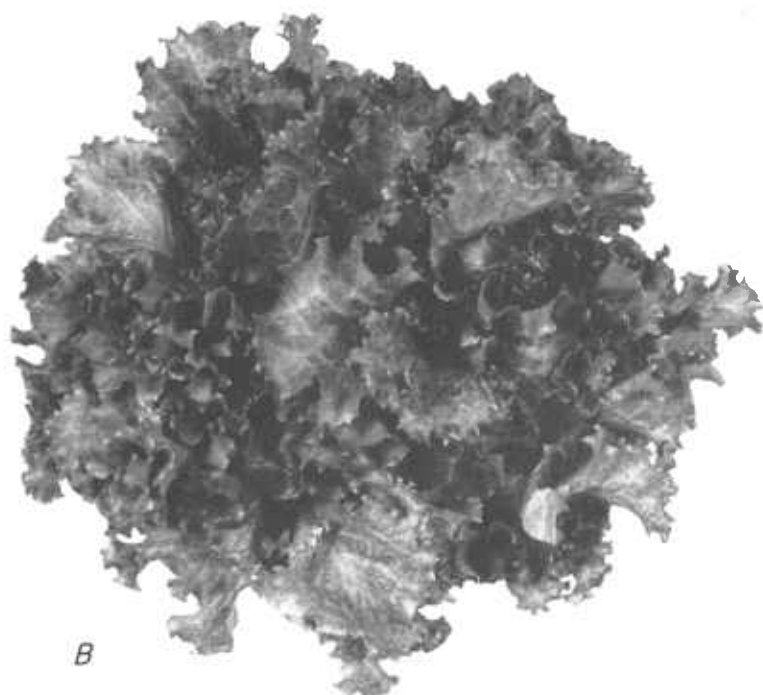


Figure 4.—Plants of the two most important varieties of lettuce grown under glass: A, Bel-May, a small butterhead variety; B, Grand Rapids, a leaf, or nonheading, variety.

In 1928 the Massachusetts Agricultural Experiment Station at Waltham developed from a cross of Belmont and May King a small butterhead variety which was released to the Boston growers as Bel-May (fig. 4, *A*). Bel-May is resistant to downy mildew and has proved to be well adapted for greenhouse culture in the Boston district. This variety constitutes a very large part of the greenhouse lettuce grown around Boston—the only district where the butterhead type of lettuce is popular with greenhouse growers.

None of the crisphead varieties of lettuce are well adapted for growing in greenhouses. Paris White, Trianon, Bath, Express, and other varieties of cos lettuce have at times been grown as a forcing crop but with limited success.

Of all the types and varieties of lettuce the leaf variety Grand Rapids (fig. 4, *B*) is the most popular and widely grown. Except in the Boston district, most of the greenhouse-grown lettuce is of strains of the Grand Rapids variety. The original strain of Grand Rapids is reported to have been developed by a large grower near Grand Rapids, Mich., by selection from Black-Seeded Simpson. There are now several strains of Grand Rapids, each adapted to particular locations and growing conditions. The Washington strain, sometimes called Grand Rapids Forcing, was developed by the United States Department of Agriculture. This strain is very popular with the Grand Rapids, Mich., growers. A strain of Grand Rapids that is adapted for forcing and is resistant to tipburn was developed by the Ohio Agricultural Experiment Station at Wooster. This strain, sometimes known as Resistant Grand Rapids, is a few days earlier than the other strains. A third strain, Grand Rapids U. S. No. 1, also developed by the United States Department of Agriculture, is an important forcing strain in New York and other forcing districts. It is also suited to outside culture. It is slower to bolt than other Grand Rapids strains.

### PRODUCTION AND CARE OF SEED

As previously indicated, only a few of the many varieties of lettuce are suitable for forcing. Only those varieties known to be adapted for forcing should be grown under glass. High-quality seed of a good strain is even more important for the forcing industry than for field production, since the cost of forcing is much greater. The supply of high-quality seed of forcing strains is often limited, and therefore many large growers have found it profitable to produce their own seed. Some growers have maintained strains of their own through many generations.

By careful selection of the most desirable plants in a population for seed production, a strain especially adapted to local conditions can be developed. Strains resistant to certain diseases, as, for example, tipburn, can be developed by carefully selecting for seed plants that are free of the disease. In working for disease resistance, selection should be made under conditions favorable for the disease and where the disease is known to be present. Fifty to seventy-five well-grown lettuce plants will produce a pound of seed. Lettuce varieties average about 350,000 seed per pound. The seed of Grand Rapids is small and well below the average in size. Only a small space is needed to grow enough plants to produce the seed to plant an average-size range of

greenhouses. A pound of high-quality lettuce seed, if properly handled, will produce enough plants to set an acre.

Plants selected for seed production should be transplanted from the beds to some part of the house where they can be given special attention (fig. 5). In a population grown for seed production, any plants not measuring up to the desired standard should be discarded. Seed plants even slightly offtype should not be saved, or the strain will deteriorate. Unless the house is screened and all insects are kept out, each individual plant should be covered with a light-weight muslin bag just before the first flowers open. The coverings should be kept on until all flowers have set seed. If the bags are left on until the seed is mature, the plants can be cut and left in the bags until seed-cleaning time.



Figure 5.—A crop of Grand Rapids lettuce seed nearing maturity in a greenhouse.

After a desirable strain has been isolated it need not be increased every year. Enough seed for 2 or 3 years can be grown and kept until used if it is stored in a cool, dry place. Lettuce seed loses its viability rapidly under humid conditions. A thoroughly dry storage space is essential if lettuce seed is to be kept more than 2 years.

### ROTATION AND INTERCROPPING

The growing of lettuce in greenhouses should be considered in relation to other forcing crops. Very few growers produce a single crop the year round. At least part of the year, most of them grow other vegetables—tomatoes or cucumbers—or some kind of flowering plants.

Lettuce is the only one of the three important vegetable forcing crops that thrives during the short, dull days of winter, and for this reason growers usually plan to have lettuce occupy the house during this period. A crop of tomatoes is often followed by a crop of lettuce, and this in turn is followed by a spring crop of tomatoes or cucumbers. Two or three crops of lettuce sometimes follow a fall crop of tomatoes.

If cucumbers are used in the rotation they are usually grown as a spring crop, when light and temperature are more favorable than during the fall and winter months. Rotation plans in common use in large ranges are given in table 1. If it is desired that lettuce be available for cutting continuously for an indefinite period, plantings should be made on several successive dates so that only part of the crop will reach cutting size at one time.

TABLE 1.—*Greenhouse crop rotations, with planting and harvesting dates*

Plan and crop	Seed sown		Plants set		Crop harvested	
Plan 1: <sup>1</sup>						
Tomatoes.....	July	1-15	Aug.	15-30	Dec.	15-31
Lettuce.....	Nov.	15-30	Dec.	15-31	Mar.	15-31
Cucumbers.....	Feb.	1-15	Apr.	1-15	July	1-31
Plan 2: <sup>2</sup>						
Tomatoes.....	July	1-15	Aug.	15-31	Dec.	15-31
Lettuce.....	Nov.	15-30	Dec.	15-31	Mar.	15-31
Do.....	Feb.	1-28	Mar.	15-31	June	1-15
Plan 3:						
Lettuce.....	Aug.	1-15	Sept.	1-15	Nov.	15-30
Do.....	Oct.	15-30	Nov.	15-30	Feb.	1-28
Tomatoes.....	Jan.	1-15	Mar.	1-15	Before Aug.	1

<sup>1</sup> The time between the removal of the cucumbers and the planting of tomatoes may be used for soil sterilization.

<sup>2</sup> In part of the space it is possible to grow a third crop of lettuce. Growers who follow this cropping plan usually count on 2½ crops of lettuce.

Since leaf lettuce can be grown to salable size in about 8 weeks from the transplanting date, it is often used for intercropping between rows of tomatoes or cucumbers (fig. 6) and is harvested before the tomatoes or cucumbers reach such size as to interfere too much with its growth.

Intercropping of lettuce presents difficulties, and the product is usually not of the highest quality. Cucumbers and tomatoes both require temperatures too high for lettuce; hence either lettuce or the crop it is grown with is likely to suffer from improper temperature. The shading effect of tall-growing tomatoes and cucumbers where the vines are trained on trellises makes growing conditions unfavorable for lettuce. In general, intercropping tomatoes or cucumbers with lettuce is not a good practice.

### GREENHOUSE SOIL AND ITS MANAGEMENT

The growing of lettuce and other vegetable forcing crops in greenhouses is an intensive and expensive operation. Maximum production must be reached quickly and maintained continuously. Most ordinary field soils are not suitable and often require modification by the addition of large amounts of organic matter, fertilizer, and lime. In some cases sand or ashes are added to change the texture and physical properties and thus to make the soil better suited for intensive crop production. Although few field soils are ideal for greenhouse vegeta-



**Figure 6.**—Leaf lettuce intercropped with cucumbers. The lettuce is to be harvested before the cucumber vines begin to run.

ble growing, if it is possible to select the soil upon which the greenhouses are to be constructed, an effort should be made to choose land which will require as little modification as possible. Where several crops such as lettuce, tomatoes, and cucumbers are to be grown in rotation in the same house the soil should be selected with the requirements of the different crops in mind. For greenhouse vegetable production the soil should be lighter than is generally considered suitable for the growing of the same crops under field conditions. The lighter soils are favored for greenhouse vegetable growing for several reasons: (1) They are more easily handled in transplanting, tilling, and sterilizing than heavy soils; (2) the surface dries off more quickly, reducing the chance that disease will become established and spread; and (3) they are more easily kept in good physical condition and, since there is less tendency for them to become packed, they afford better aeration.

Where the original soil is too heavy it should be made more friable by incorporating sand and well-decomposed organic matter. Muck is ideal for supplying organic matter and making soil more friable. However, muck alone is not suitable for vegetable forcing.

Good drainage is essential. Unless the land selected for the greenhouse site is already well drained, proper drainage should be provided for at the time the house is constructed. Tile installed for drainage may also be used for soil sterilization and if underlain by a heavy soil can be used for subirrigation.

#### SOIL STERILIZATION AND DISINFECTION

With the intensive crop production practiced in the greenhouse forcing industry, where two or three kinds of crops and sometimes a single crop are grown almost continuously on the same soil, the disease hazard is very great. The control of plant pests under greenhouse conditions is more necessary and sometimes more difficult than under open-field conditions. Soil sterilization or disinfection for the con-

trol of diseases, insects, nematodes, and other plant pests is practiced almost universally by greenhouse growers. Greenhouse soil should be sterilized or disinfected at least once a year at whatever period it can be done with the least interference with crop production; this is usually during the summer months, when high temperatures are unfavorable for greenhouse crops.

#### Steam Sterilization

Sterilization with live steam is the most effective and widely used method of controlling soil-borne plant pests. Most large forcing greenhouse ranges are equipped to sterilize with steam. New construction should be provided with such equipment. Steam can be applied by several methods. The most generally used devices for applying steam for soil sterilization are (1) the inverted pan, (2) perforated iron pipes, and (3) drain tile. The method to be used must be determined largely by the conditions.

The inverted pan, one of the oldest devices for soil sterilization, is still in use. It is best adapted for porous soils, which offer the least resistance to penetration by steam. The equipment consists of wooden or metal pans of almost any convenient size. The pans should not be so large as to be difficult to move. Galvanized sheet iron is more durable and lighter than wood.

Convenient-size pans are 4 to 6 feet by 10 to 12 feet and 6 to 8 inches deep. The size and shape of the pans, however, should be determined by the dimensions of the planting beds, the capacity of the boiler, and the means of moving the equipment. Each pan is provided with a pipe connection for the attachment of the steam hose. It is inverted, and the edges are forced into the soil a few inches to prevent the escape of steam. If the steam pressure is high, it may be necessary to add some additional weight to hold the pan in the soil. Some large growers have pans equipped with wheels and a mechanical lifting device by which the apparatus is lifted and rolled when it is necessary to move the pans (fig. 7).

There are many modifications of the perforated-pipe type of equipment in general use. The perforated-pipe arrangement consists of four to six perforated  $1\frac{1}{4}$ - or  $1\frac{1}{2}$ -inch iron pipes 20 to 70 feet or more in length fastened to a 2-inch header pipe at spacings of 12 to 18 inches. The perforations are usually either  $\frac{1}{8}$  or  $\frac{1}{4}$  inch. The size of the equipment is determined by the size of the house, boiler capacity, and help available for moving. This equipment is buried to a depth of 6 to 10 inches in the soil, and the entire surface is covered with a heavy canvas to confine the steam. If two or more sets of equipment are available, one set can be buried and made ready while sterilization is going on in another section. The chief objection to this method of sterilization is the great amount of labor required in burying the pipes.

A variation of this method is soil sterilization by perforated pegs, known as the rake, or steam-harrow, system. This equipment consists of a framework of metal pipes constructed of a series of reducing nipples with T's at intervals of 6 to 8 inches to which about 6-inch lengths of small iron pipe, usually  $\frac{1}{2}$ -inch, are connected. The lower ends of these small pipes are closed by flattening to form wedges, and a  $\frac{1}{8}$ - or  $\frac{3}{16}$ -inch hole drilled through each just above the wedge pro-

vides openings for the escape of steam. The header line is provided with a connection for attachment to the steam hose. The pegs are forced into the soil, and the surface is covered with a heavy canvas to confine the heat. Where the boiler capacity is sufficient to supply the steam, a number of these rakes can be operated continuously by a group of workmen. The rake is especially well suited for small houses and ranges having raised benches.

Four-inch drain tile set about  $1\frac{1}{2}$  feet deep in rows  $1\frac{1}{2}$  to 2 feet apart can be used for both steam sterilization and subirrigation. Tile lines may be a source of trouble, however, because they provide a shelter and breeding place for crickets, roaches, and other pests.

The object of soil sterilization is to kill all living organisms that may be injurious to plants. The eggs of some insects and the spores

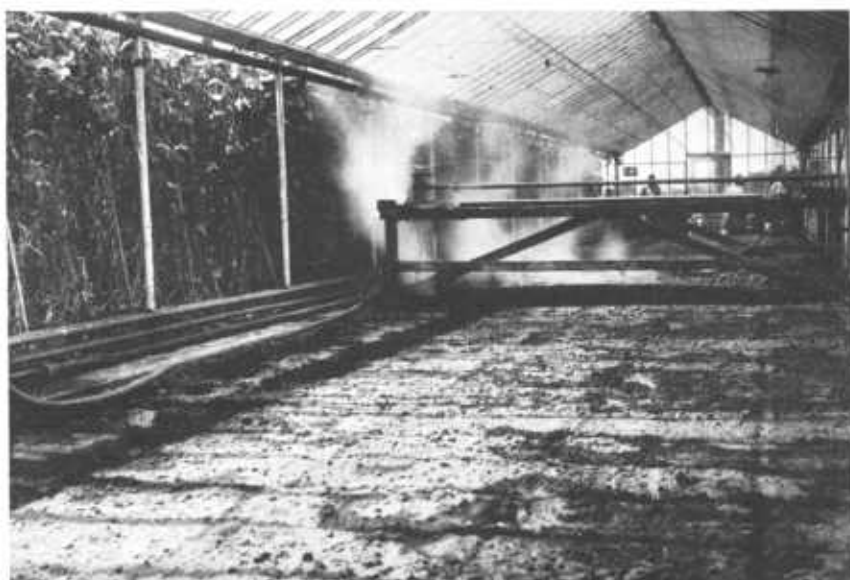


Figure 7.—Mechanically movable steam pan being used for sterilizing greenhouse soil. The equipment is lifted by a special hoist and moved to a new location on wheels, which roll on the concrete walks.

of some disease-producing organisms are very resistant to heat. In order to destroy the most resistant plant pests, it is necessary that all the soil to a depth of several inches be heated to  $212^{\circ}$  F. for a period of half an hour or more. The time required for the soil to reach a temperature of  $212^{\circ}$  will depend on the steam pressure, soil texture, and type of equipment used. Steaming for a longer period than is required to kill plant pests should be avoided. Excessive heating breaks down organic materials and leaves the soil in a poor condition for the growing of plants. Plant growth is more satisfactory when steam-sterilized soil is permitted to lie 3 to 4 weeks before it is used.

#### Disinfection by Chemicals

Soil can be sterilized by live steam or by such chemicals as chloropicrin. Other chemical disinfectants can be used to control certain

plant pests, but they do not do so thorough a job as steam or chloropicrin, both of which kill nearly all disease organisms, weed seeds, insects and their eggs, and even nematodes.

**Chloropicrin is a highly volatile, toxic gas and must be handled with care. It is not generally recommended for use indoors. It can be used to sterilize compost piles outside with less danger.**

For the control of nematodes alone the following chemicals are all effective when properly applied: Dichloropropene mixtures (known commercially as D-D and Dowfume N), ethylene dibromide (known commercially as Dowfume W-40 and W-10, Iscobrome D, Soilfume, and Bromofume), and methyl bromide (known commercially as Dowfume G and Iscobrome No. 1). However, these are not very effective as fungicides. Formaldehyde made up of 1 pint of commercial formalin to 50 gallons of water applied at the rate of  $\frac{1}{2}$  to 1 gallon to each square foot of soil surface is effective in controlling damping-off and some other plant diseases but is not very effective in destroying nematodes.

**Most chemical disinfectants are toxic to man, and caution should be exercised in using them. It is advisable to consult the agent of the chemical company whose product is being used, the county agricultural agent, or the State agricultural college specialists when chemical sterilization is to be done if the handling of the material is not already well understood.**

Soil that has been treated with chemicals should not be used for the growing of plants until all of the gases have escaped. The period that must elapse after chemical treatment of soil before it is safe to use for the growing of plants is variable, depending on the fumigant used and its concentration and on the type of soil and its temperature and moisture content. Generally 2 to 3 weeks should be allowed for the gases to escape before the soil is used for the growing of plants, although a light application of methyl bromide may escape in a few days.

#### SOIL PREPARATION

The intensive cropping system practiced in greenhouses requires that the soil be highly fertile and that it be put in the best physical condition possible. Unless the greenhouse range is located on soil suitable for forcing crops, the soil may require modification by the addition of sand as well as organic matter and fertilizer before it can be made highly productive. In large ranges where the crop is grown in ground beds the soil remains in place from year to year. Its productivity is maintained by the addition of manure or other organic matter and fertilizer and by sterilization.

The best soil for forcing crops is one naturally deep, well-drained, and friable. Animal manure is the best source of organic matter, and if it can be obtained, it should be applied at the rate of 1 ton to each 1,500 square feet of surface, or about 30 tons per acre. Because of the increasing scarcity and cost of animal manure, greenhouse growers have found it necessary to find substitutes for part of the organic matter and to supplement manure with chemical fertilizers. Muck is a good source of organic matter and can be used as a substi-

tute for manure if supplemented with chemical fertilizer. The Ohio Agricultural Experiment Station has conducted experiments which indicate that larger yields of lettuce are obtained by the use of 30 tons of manure per acre than by the use of chemical fertilizers alone. However, these experiments also show that good results can be obtained when the manure application is reduced to 15 tons per acre provided it is supplemented by an annual application of half a ton per acre of a 3-12-4 fertilizer or of a complete commercial fertilizer having a similar formula.

Experimental evidence shows that phosphorus is frequently a critical element in the production of lettuce. Except on highly fertile soils already well supplied with phosphorus, lettuce yield generally increases with an application of phosphorus in an available form. Phosphate for lettuce is better applied in the form of superphosphate than in the less soluble forms of bonemeal and ground rock phosphate. Foliage crops like lettuce use large amounts of nitrogen, but overfeeding with available forms of nitrogen such as nitrate of soda and sulfate of ammonia should be avoided. Excessive stimulation with nitrogen causes a rank, succulent growth that is subject to disease. Lettuce does not have a high potassium requirement; however, best results with lettuce are generally obtained when a complete fertilizer supplying nitrogen, phosphorus, and potassium in the proportion of about 1 part of nitrogen, 2 or 3 parts of phosphorus, and 1 part of potassium is used.

Where heavy application of chemical fertilizer is made, the fertilizer should be spread uniformly and thoroughly worked into the soil before planting. Side dressing with nitrate of soda or sulfate of ammonia after the crop has become established should not exceed about 200 pounds per acre. Continued use of large amounts of nitrate of soda may in time result in toxic residues.

Lettuce is more sensitive to soil reaction than are either tomatoes or cucumbers. When tomatoes or cucumbers are grown in rotation with lettuce on the same soil, attention should be given especially to the requirement of lettuce, which does best on soils only slightly acid. If the soil is moderately or very acid, the acidity should be corrected by the application of lime. Experience indicates, however, that heavy applications of lime may be injurious to lettuce. It is usually unsafe to exceed the amount indicated by lime-requirement tests. The county agricultural agent or the soils department of the State agricultural college will usually make the required tests for the grower.

Lime may be applied as ground limestone, ground burned limestone, or hydrated lime. Ground burned limestone gives the quickest results and the greatest change in soil reaction. Ground limestone is slow in its reaction. About one-half as much burned limestone or about three-fourths as much hydrated lime is required to give the same change in soil reaction as a given quantity of ground limestone. Once the soil in a greenhouse has been brought to the proper condition of acidity a moderate application once a year as indicated by lime-requirement tests will generally maintain a satisfactory soil reaction. More lime will be required when acid-forming materials like sulfate of ammonia are used in the fertilizer than when base-forming materials are used.

## STARTING THE PLANTS

Greenhouse lettuce is usually grown from transplants rather than by seeding in the beds where the crop is to be grown. Enough seedlings for an entire range can be grown in one house, where more uniform growing conditions can be maintained. This leaves a large part of the range available for other crops while the lettuce plants are being started.

The seedlings are grown on solid beds or raised benches with or without the use of flats. Better plants can generally be obtained if flats are used, and they are more easily handled.

### SOIL FOR SEEDLINGS

A good grade of composted soil should be used for starting the plants. The compost pile should be prepared several months or preferably a year in advance. This prepared soil should be free of large clods, stones, or trashy organic matter. Two parts of field sod to one part of stable manure, preferably horse or cattle manure, makes a good compost. If the soil tends to be heavy, some sand should be added to make it more friable. If the soil is acid, ground limestone to correct the condition should be added to the compost pile. It is generally desirable to add a few pounds of a complete fertilizer high in phosphorus to each ton of compost. A 5-10-5 fertilizer or one having a similar analysis is suitable. The compost pile should be cut down and turned once and preferably twice to incorporate the manure thoroughly. The lime and fertilizer can best be added at the first turning.

Large ranges are equipped with soil shredders through which the compost is passed before it is used for planting. If the prepared compost contains coarse material, it should be passed through a screen. It is advisable to sterilize all compost used for starting the plants, although this is not always done. An entire range may be infected with a disease that has its origin in the plant bed or seed flat.

It is important that the soil used for the starting of the plants be friable enough to fall apart readily and permit the separation of the seedlings with a minimum of root injury. Small plants start off more rapidly after transplanting and are much less subject to injury by soil-borne organisms if the root system is kept intact than if the roots are broken and otherwise injured. Soil for the starting of plants should be lighter and more friable than is considered desirable for crop production.

### PLANTING THE SEED

Since greenhouse lettuce does not sell well until local field-grown lettuce is off the market, the fall crop should be set so as to be ready to harvest soon after the field-grown crop is off the market. About a month is required to produce plants for setting. The time required to grow a crop of lettuce to marketable size depends to a large extent upon the season of the year. Growth is slower and more time is required to produce the crop during the short days of winter than when the days are brighter and longer. When lettuce is not grown with other crops seed should be planted August 1 to 15 for a crop to mature the latter part of October or early November. In large ranges where several crops are grown during the fall, winter, and spring, planting and harvesting go on continuously and several plantings are necessary.

Lettuce seed may be planted broadcast or in drills. Drill planting is preferable. The seed should be dropped at the rate of 8 to 12 per inch in very shallow furrows spaced about 2 inches apart. A suitable planting furrow can be made with the edge of a thin piece of wood such as a lath. The seed should be covered to a depth of not more than  $\frac{1}{8}$  inch with muck or leafmold mixed with sand. Light material like muck is not a good covering when used alone as it is too light and has a tendency to lift in a sheet as the seed germinates, and therefore a weak, elongated seedling may result. Such material as muck mixed with sand to add weight makes an ideal cover for lettuce seed, since the muck when once wet has a strong tendency to hold moisture. Sometimes burlap or other cloth is substituted for the soil covering and is thoroughly wet after being laid. This will help hold moisture until the seed germinates. When cloth is used, it is essential that it be removed as soon as the seed starts to germinate.

#### SEED TREATMENTS TO IMPROVE GERMINATION

The germination of some lettuce seed is very uncertain. The seed of many varieties of lettuce germinates poorly if planted soon after harvest and requires a month or two of afterripening in storage under dry conditions before it will give good germination. Some lettuce seed has a more or less permanent dormancy or tendency to germinate poorly at temperatures of 75° F. or above. This is especially true of the variety Grand Rapids, which is very widely used for greenhouse forcing. After harvest nearly all lettuce seed should be held for some time before planting.

Where temperature in the greenhouse can be controlled, it should be held below 70° F. until the lettuce seedlings have emerged above ground. Good, viable, nondormant lettuce seed will germinate in less than 24 hours at temperatures between 65° and 70°. At higher temperature most lettuce seed will require at least 2 or 3 days for emergence.

If lettuce seed known to exhibit dormancy is to be planted when temperatures cannot be held below 75° F., germination can be greatly improved by soaking the seed in a  $\frac{1}{2}$ -percent solution of thiourea for 8 to 10 hours at 65° to 70°. The seed may be planted while damp after removal of the solution, or it may be scattered out thinly on a dry surface and after drying kept until planting time. The increase in germination due to the thiourea treatment will remain effective for several months if the seed is stored in a cool, dry place. Similar treatment with water alone will aid in the germination of most lettuce seed.

Dormant lettuce seed can be made to germinate more readily if given a cold treatment just before planting. It has been shown that dormant lettuce seed soaked in water for 2 or 3 hours and then held at 4° F. with good aeration for 4 to 6 days is greatly improved in germination. With the cold treatment the seed cannot be dried off and stored but must be planted while moist to benefit from the treatment.

#### PRICKING OFF AND TRANSPLANTING

Greenhouse lettuce is usually transplanted twice, (1) from the planting bed or seed flats to other flats and (2) from these flats to the beds where the crop will be grown. Transplanting is expensive, but it produces better plants. The first transplanting, or pricking

off, is done about a week after emergence of the seedlings. The interval between emergence and pricking off depends on growth rate and thickness of seeding. If the seedlings are close together and the temperature in the house is high, it will be necessary to prick off sooner than if the house is cool and the plants are not crowded. If vigorous, stocky plants are to be obtained, pricking off must not be delayed until the seedlings begin to crowd. The less the roots of the seedlings are broken or injured in lifting from the plant beds or flats, the sooner they will recover after pricking off.

The seedlings are sometimes pricked off into small pots or paper bands, but the common practice is to shift them into standard planting flats (fig. 8). Planting flats of various sizes and dimensions are



Figure 8.—Plants for a 10-acre range pricked off into flats and placed on a greenhouse bed.

in use. About 2 inches should be allowed between the plants in the flats. The flats in general use hold 60 to 75 plants at the 2-inch spacing. Experienced workers can prick off as many as 5,000 plants a day. As soon as the plants are set in the flats, the soil should be watered. It is important that the first watering be thorough. Enough water should be applied to wet the soil to the bottom of the flat. The water should be applied as a very fine spray so as not to injure the plants by covering the leaves with mud. This is doubly important if the plants are wilted.

### ESTABLISHING THE CROP PLANTS

After being pricked off from the seed flats or planting beds, the seedlings should remain in the growing flats or pots until good, sturdy plants have developed but not until they are crowded. Holding too long before the final transplanting results in elongated, bleached plants that are stunted and start off slowly. The number of plants required to set a given area depends upon the planting distances used (table 2). Planting distances of 7 by 7 inches to 9 by 9 inches are generally used. Some growers plant closer in one direction than in the other, to make cultivation somewhat easier. Planting in squares gives the plants uniform opportunity for development.

TABLE 2.—*Lettuce plants required per 1,000 square feet and per acre*

Distance apart	Plants for—		Distance apart	Plants for—	
	1,000 square feet	1 acre		1,000 square feet	1 acre
	<i>Number</i>	<i>Number</i>		<i>Number</i>	<i>Number</i>
6 by 7 inches-----	3, 429	149, 368	7 by 8 inches-----	2, 571	111, 993
6 by 8 inches-----	3, 000	130, 680	7 by 9 inches-----	2, 286	99, 579
6 by 9 inches-----	2, 667	116, 175	8 by 8 inches-----	2, 250	98, 010
7 by 7 inches-----	2, 939	128, 023	8 by 9 inches-----	2, 000	87, 120

A much greater number of plants is required where close planting is practiced (table 2). The greater number of plants required for close planting adds to the cost of plants and increases the chances for disease; and it may not increase the total yield per unit area enough to justify the practice.

In setting the plants in the greenhouse beds, some kind of marker for spacing the plants accurately is essential. One such device (fig. 9) consists of a broad board having wooden pegs  $1\frac{1}{2}$  inches in diameter and about 2 inches long attached at the desired planting distances. It speeds the work of setting and assures accurate spacing of the plants. The workers kneel on the board while they are transplanting; while plants are being set in holes already made, another series of holes is made.

An effort should be made to retain as much soil as possible on the roots in removing the plants from the flats so that there will be a minimum check in growth. Running a knife through the soil between



Figure 9.—Setting lettuce plants in the greenhouse. The board marker serves as a support for the workers as well as a marker for spacing the plants.

the plants in both directions helps to retain the soil around the roots. Too deep setting of lettuce plants is ruinous. It is better to set them a little shallow than too deep. The soil should come not quite to the bottom pair of leaves. Leaf petioles and blades are much more subject to decay by soil organisms than stems.

## GENERAL CARE OF THE CROP

### WATERING

Lettuce, which requires a great deal of water, should never be permitted to suffer from want of moisture. Thorough irrigation is much better than frequent light wettings. Frequent wetting of lettuce leaves tends to spread diseases. Drop, bottom rot, gray mold, and mildew are all favored by moisture. The sooner moisture can be dried from the leaves after wetting the better. There is less danger of foliage diseases getting started in lettuce during the early stages before the plants cover the soil and when ventilation and air movement are good. Subirrigation is ideal for lettuce in that moisture can be kept off the leaves.

Many vegetable forcers have installed overhead sprinkling systems. Overhead irrigation insures more uniform distribution of water, reduces labor costs, and provides less chance for damage to plants than hand-operated nozzles.

Pipe lines equipped with sprinkling nozzles spaced about a foot apart are fastened to the supporting parts of the house. A single line of pipe will handle a 40- to 50-foot width of greenhouse space. By inserting a swinging joint near the valve end, the entire line can be rotated so as to cover all the space between the lines.

### VENTILATION AND TEMPERATURE

Lettuce is a cool-season crop and thrives best at relatively low temperatures. High temperature favors rapid growth but increases the chances for disease, and too high temperature may cause weak, spindling plants. Temperatures may be high with less danger during the early stages of growth than when the plants have reached a large size and air movement between them is reduced. It is important that temperatures be held low as the crop nears maturity.

Lettuce does not like a constant temperature. There should be a spread of 10° to 15° F., and perhaps more, between day and night temperatures; however, sudden changes in temperature should be avoided. The exact temperatures that should be maintained within a house for the growing of lettuce must be determined to some extent by conditions outside, as they affect the amount of ventilation that can be used. After irrigation, when the humidity within the house is high, it is best to maintain the temperature a few degrees lower than could be permitted if the foliage were dry and the humidity low. Night temperatures of 45° to 50° and day temperatures 15° higher are satisfactory for lettuce during the winter. In early fall and late spring, however, it may be impossible to maintain these optimum temperatures.

The control of ventilation is very important in the successful production of lettuce in greenhouses. Lettuce should be ventilated as much as outside conditions will permit. The top vents should never

be closed absolutely tight except during periods of very low temperature or in stormy weather. Stagnant, humid air is a contributing factor in the development of some diseases of the greenhouse lettuce.

#### CULTIVATION

The removal of weeds, one of the chief purposes of cultivation of crops grown in the open, is generally not a problem in greenhouses. Once the soil in a house has been steam-sterilized, weeds should not be troublesome unless their seeds are introduced in manure and other materials used in preparing the soil. Shallow cultivation to break up the surface crust may be beneficial while the plants are small, especially if the soil contains considerable clay. After the plants have begun to cover the soil, however, cultivation may do more harm than good. Cultivation is usually done with ordinary hand tools. Long-handle tools can be used on narrow beds, but some kind of trestlework on which workmen can stand is desirable for wide beds. If the spacing is wide, wheel hoes may be used for cultivating small plants.

#### HARVESTING AND MARKETING

The time required to produce a crop of lettuce from the time of transplanting to the greenhouse beds ranges from 6 to 12 weeks, depending upon the market demand as regards plant size and the season of the year. Under certain market conditions when prices are good, it may be profitable to harvest before the plants reach maximum size even though this means some loss in total yield. When lettuce is sold by weight, growers like to allow the plants to reach as large a size as possible without reduction in quality. Market demand and current prices determine to a large extent the time of harvesting. A longer time is required to produce plants of marketable size during the short days of winter than during the sunnier, longer days of summer. If another lettuce crop is to follow the one about ready to harvest, the condition of the seedlings for the next crop may make it necessary to harvest earlier than otherwise to avoid damage from holding the seedlings in a crowded condition.

In harvesting, the plants are cut just above the soil surface with a short-blade knife. Sometimes the plants are trimmed and packed in the greenhouse as they are harvested (fig. 10). Most large establishments, however, are equipped with washing and packing sheds; in that case, only the spoiled and dirty outer leaves are removed in the house. The plants are placed in containers and taken to the shed where they are trimmed, washed, and packed for market (fig. 11).

The washed plants are packed wet, as some moisture is required to keep them fresh in transit. If the packing containers have tight bottoms, holes should be provided to permit the escape of the water that collects at the bottom.

There is no established standard container for packing and shipping greenhouse lettuce. Various kinds of packages, baskets, hampers, boxes, and barrels have been used as shipping containers in the past. Rectangular 24-quart splint baskets holding about 10 pounds of lettuce are in general use by Ohio growers. Large containers are generally lined with heavy paper (fig. 12). Paper linings afford some protection from freezing when lettuce is shipped in cold weather. The con-



Figure 10.—Lettuce being washed and packed in barrels in the greenhouse.

tainer covers are of paper to prevent wilting of the lettuce before it is placed on the market.

The profit to be expected from a given unit area of greenhouse lettuce depends on many factors—labor, fuel, fertilizer, and other production costs, market demand, quality of the product, and yield. Any estimate of profit that might be expected could only be a very rough approximation. About a pound of lettuce per square foot of greenhouse space is considered a good yield. Yield per unit area depends very largely upon the stage of development at which the crop is harvested. In order to obtain a yield of a pound per square foot of space, the plants must be permitted to reach near-maximum size before cutting. Market demand and prices may make it more profitable to harvest smaller plants even though the total yield is reduced.



Figure 11.—Harvesting lettuce in bushel baskets for removal to the packing shed, where it is to be trimmed, washed, and packed.

DISEASES OF GREENHOUSE LETTUCE <sup>2</sup>

## DROP

Drop <sup>3</sup> is possibly the most serious disease of lettuce in the greenhouse. It is characterized at first by a wilting of the outside leaves, usually followed rapidly by the wilting and collapse of the entire plant. Affected plants show a soft watery rot of the stems and leaves near the surface of the soil; these decayed parts are usually covered by conspicuous cottony white wefts of fungus or mold in which are developed black seedlike bodies, called sclerotia.

The disease is particularly likely to cause trouble during damp, cloudy weather. Too high temperature, improper ventilation, over-watering the crop, and crowding the plants in the beds tend to in-



Figure 12.—Leaf lettuce packed in paper-lined barrels in the greenhouse, with portable washing equipment at side.

crease the ravages of the disease. Proper management of the crop, especially the sparing use of water during the 3 or 4 weeks before harvest, tends to hold the disease in check. It is advisable that diseased plants, including taproots and surrounding soil, be removed and destroyed as soon as evident, in order to check the spread of the disease to adjacent plants and prevent the formation of the seed-like fungus resting bodies which remain in the soil and produce the disease in succeeding crops. If drop causes heavy losses, a practicable and very effective remedy is the sterilization or disinfection of the soil, preferably by steam, chloropicrin, or formaldehyde (p. 9). The use of fresh soil serves the same purpose, if the soil is disease-free.

<sup>2</sup> Originally prepared by the late Ivan C. Jagger, formerly senior pathologist, Division of Fruit and Vegetable Crops and Diseases.

<sup>3</sup> Caused by *Sclerotinia sclerotiorum* (Lib.) DBy. and *S. minor* Jagger.

**BOTTOM ROT**

Bottom rot <sup>4</sup> is destructive in some sections, especially on heading varieties of lettuce, which grow with the outer leaves resting on the ground. The disease is characterized by a brown soft rot of the leaves, beginning where they rest on the ground and extending into the head. It is distinguished from drop by the absence of white wefts of mold and by the fact that the stem of the plant is not rotted. It is favored by moisture and can often be satisfactorily controlled by care in watering, especially by using no more water than is essential for the growth of the crop after the plants begin to shade the ground. When this treatment is not effective, it is necessary to resort to soil treatment, as for drop.

**GRAY MOLD**

Gray mold <sup>5</sup> is less likely to become a problem if the plants are kept in a vigorous growing condition than if they are weakened by other diseases or by unfavorable growing conditions. It is characterized by a brown soft rot, and in advanced stages the affected parts are covered with a grayish mass of fungus growth. Gray mold often follows tipburn, as the causal fungus readily gains entrance through the dead areas caused by tipburn at the leaf margins. Soil treatment may help to control or delay the development of the disease.

**MILDEW**

Lettuce mildew <sup>6</sup> is characterized by yellowish or brownish spots in the outer leaves, covered on the lower surface and sometimes on the upper by a white fuzzy fungus growth. Insufficient ventilation, overwatering, and fluctuating temperatures are likely to induce trouble from this disease. As a rule careful management of the houses and the crop is effective in controlling mildew.

**ANTHRACNOSE**

Anthracnose <sup>7</sup> is known also as shot hole, or rust. It results in brown, roughly circular spots on the leaves, the brown tissues often falling out and producing shot holes, or sunken spots on the midribs. The disease is favored by overwatering, especially when water is applied as a coarse spray which spatters soil on the plants, and by low temperatures. Remedial measures include the sparing use of water and the application of water as a fine mist, in a slow stream from a hose, or by subirrigation to prevent spattering soil on the leaves.

**ROSETTE**

Rosette causes considerable loss to lettuce growers. The disease is caused by the fungus <sup>8</sup> that causes bottom rot. It lives on the roots, interfering with the nutrition of the plants and resulting in dwarfing and stunting. The disease is often induced by improper setting, faulty fertilization, or poor soil conditions.

<sup>4</sup> Caused by *Rhizoctonia solani* Kuehn.

<sup>5</sup> Caused by *Botrytis cinerea* Fr.

<sup>6</sup> Caused by *Bremia lactucae* Regel.

<sup>7</sup> Caused by *Marssonina panattoniana* (Berl.) Magn.

<sup>8</sup> *Rhizoctonia solani*.

### TIPBURN

Head lettuce, and to a less extent leaf lettuce, is subject to tipburn, or dying and browning of the margins of the leaves making up the central part of the plant. The primary cause of the disease is too high temperature, although an excessive amount of nitrogenous fertilizers, especially when there is a deficiency of other fertilizer elements, makes crops more susceptible. Tipburn easily results from a few days of dark, cloudy weather during which the houses are run at rather high temperatures with little or no ventilation and the growth is rapid and watery. Somewhat lower temperatures than normal and adequate ventilation during dark, cloudy weather prevent tipburn during the winter. If outside temperatures are too high during the fall and spring, care in fertilizing, watering, and ventilating to obtain as solid and firm growth as possible will help to hold the disease in check.

### ROOT KNOT

Root knot<sup>9</sup> has never been considered particularly destructive to greenhouse lettuce, but it must be controlled if the best results are to be obtained. During the winter lettuce houses are usually run at such a low temperature that the disease remains dormant and does no damage, but during the warmer weather of fall and spring root knot may cause serious injury. It is very injurious to both cucumbers and tomatoes, and when one or both of these occupy a place in the greenhouse rotation it is especially desirable that the disease be controlled.

Steam sterilization of the soil is an effective control measure if carried out carefully and thoroughly. The microscopic nematode, or eelworm, causing this trouble works down to a depth of a foot or more and penetrates under walks and side walls. Satisfactory results cannot be expected unless the soil is heated at a temperature of at least 212° F. to a depth of at least a foot.

More recently fumigation of the soil with one of the newer chemicals has been proving very successful and, in many instances, not too costly.<sup>10</sup> It is further discussed under Soil Sterilization and Disinfection (p. 9).

## INSECTS INJURIOUS TO GREENHOUSE LETTUCE<sup>11</sup>

Lettuce grown in the greenhouse is subject to injury by several insect pests. The most troublesome are plant lice, or aphids, and whiteflies, which frequently cause serious damage unless they are checked. The cabbage looper and cutworms occasionally gain entrance to greenhouses and cause considerable injury.

### PLANT LICE AND WHITEFLIES

#### Hydrocyanic Acid Gas Fumigation

An effective and cheap method of ridding vegetable houses of whiteflies and plant lice is fumigation with hydrocyanic acid gas. **This gas**

<sup>9</sup> Caused by the nematode *Heterodera marioni* (Cornu) Goodey.

<sup>10</sup> See CHRISTIE, J. R. SOIL FUMIGATION FOR CONTROL OF NEMATODES AND OTHER SOIL-INHABITING ORGANISMS. U. S. Bur. Plant Indus., Soils, and Agr. Engin., Plant Dis. Rptr. Sup. 170: [169]-189, illus. 1947. [Processed.]

<sup>11</sup> Prepared by C. A. Weigel, senior entomologist, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration.

**is very poisonous, and there is grave danger to the operator and also to the plants being fumigated unless extreme care is exercised in handling the material.** However, in experienced hands it is a safe, practical, and economical fumigant. One-eighth to one-fourth ounce of calcium cyanide per 1,000 cubic feet of air space, depending on the tightness of the house, should be used during an overnight fumigation with the gas it produces. As this dosage does not kill immature forms of whiteflies, repeated treatments will be necessary to kill the adult flies after they emerge from the pupal stage. More detailed information on the proper method of fumigating with this material can be obtained by consulting your State entomologist or the Bureau of Entomology and Plant Quarantine, Washington 25, D. C.

#### Nicotine Fumigation

Nicotine fumigation is used extensively and effectively for the control of plant lice infesting greenhouse crops. This method, while convenient, is usually more expensive than hydrocyanic acid gas fumigation. The nicotine is made available by various methods, either by burning tobacco stems, specially prepared paper or powder treated with nicotine, or finely ground tobacco dust or by vaporizing liquids containing nicotine on special burners or hot steam pipes.

Nicotine papers or powders, tobacco dusts, and tobacco or nicotine liquids prepared for fumigating purposes contain varying proportions of nicotine, and it is advisable to follow the directions for their use as given by the manufacturers. The grower is advised to observe carefully the results obtained and if the fumigation is not effective to increase the quantity of material.

**Nicotine and its compounds are violent poisons, and care should be exercised in their use.**

#### CABBAGE LOOPER

The cabbage looper,<sup>12</sup> one of the caterpillars commonly found on cabbage, often gains entrance to greenhouses by being inadvertently carried there; or the moth may enter the house in late fall and deposit eggs upon lettuce or other food plants.

When attacked by these caterpillars, the lettuce should be dusted with derris or pyrethrum dusts.

A dust containing 1 percent of rotenone is effective and may be prepared by mixing 10 pounds of derris, or cube, powder containing 4 percent of rotenone with 30 pounds of talc or pyrophyllite dust. Obviously, a powder containing a higher or lower percentage of rotenone should be mixed with correspondingly more or less of the inert material to give a 1-percent mixture.

The pyrethrum powder mixtures used should be freshly prepared. These mixtures standing for a year after preparation lose a high degree of their effectiveness.

If the insects are successfully controlled during the first outbreak, there will be little danger of their recurrence during the season.

<sup>12</sup> *Trichoplusia ni* (Hbn.).

# CUTWORMS

Cutworms usually gain access to the greenhouse by being transported in the soil, but moths may enter the house late in the season and deposit the eggs from which the caterpillars develop. Cutworms can be controlled by the use of poisoned bait prepared as follows:

Sodium fluosilicate or paris green.....	¼ pound.
Dry wheat bran.....	1 peck, or 5 pounds.
Water .....	3 or 4 quarts.

(1) Thoroughly mix the poison with the bran. This is important. To be effective, each particle of bran must carry a little poison. Small quantities can be mixed in a bucket with a paddle; the bran should be stirred while the poison is added slowly. **If the hands have any cuts, scratches, or other wounds, do not let the bait touch them.**

(2) Add the water to the mixture of bran and poison, stirring slowly all the time. Large quantities of water added at one time will wash the poison from the bran, and an uneven mixture will result.

Only enough water to make a crumbly mass should be used. It is a good plan to set aside a little of the mixture of dry bran and poison, so that if too much water is used this dry reserve can be added to bring the mixture to the proper consistency.

The poisoned bran should be scattered lightly and evenly over the surface of the bed between the lettuce plants late in the evening. Care should be taken, however, to prevent it from coming in contact with the plants.

**Remember that cutworm bait is poisonous and keep it away from children, livestock, and poultry. The poisonous ingredient, paris green or sodium fluosilicate, should be handled with care and kept away from food.**

